SCIENTIFIC REPORT D 6.9

Reference buildings- The Austrian building typology

A classification of the Austrian residential building stock.

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1 The project background

The aim of the EU climate and energy package is to achieve an overall 20% reduction of greenhouse gas emissions as compared to 2005, by 2020. According to the burden sharing agreement, Austria's national goal is a 16% emission reduction of the non- ETS sector within this period. Among the targets for the national space heating sector, a thermal refurbishment rate of 3% (at the moment about 1%) and an increased use of renewable energy have been fixed.

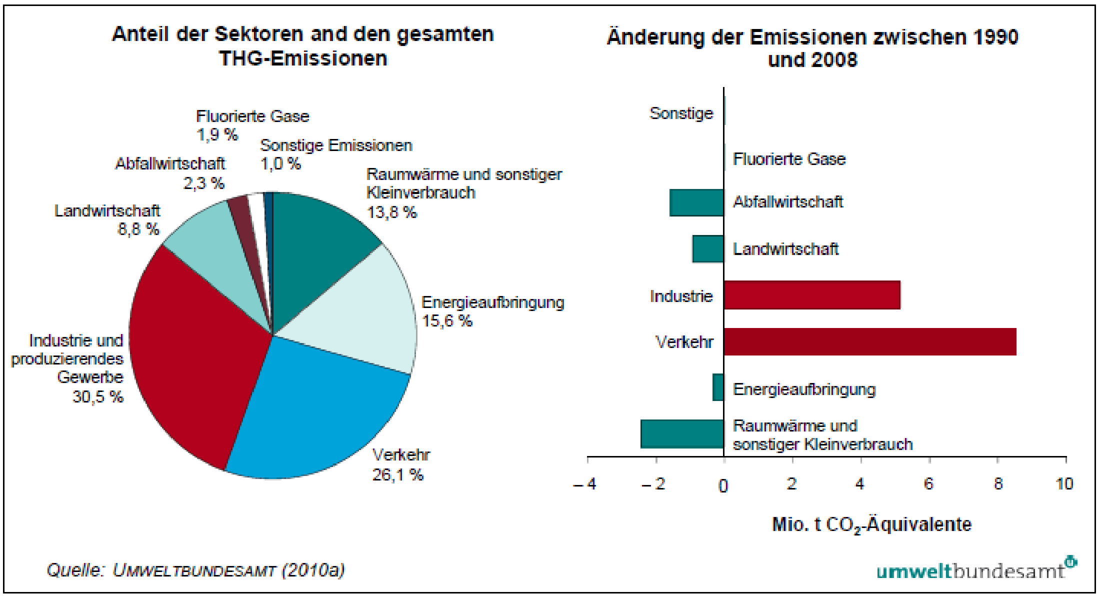

Figure 1: Percentage of sectors in the national GHG emissions in 2008 and changes in emissions in the sectors between 1990 and 2008

Presently about 13.8% (the average in 2002–2008[1]) of the Austrian CO_2-emissions are caused in the sector "heating and domestic hot water" [see figure 1].

Therefore, a tool is needed to easily identify the buildings with the highest CO_2 emissions reduction potential. Additionally, the measures leading to the most wanted results have to be defined. That implies that decisions on modernisation strategies on local, regional and national level should be based on detailed scenario analyses in order to maximise the impact of the activities.

A precondition for such calculations is the availability of information about the energy performance of the existing building stock. A suitable information tool builds upon a database structure, and a harmonised approach within the EU will be advantageous for comparison of different national refurbishment strategies.

[1] "Klimaschutzbericht 2010" : Austrian climate protection report 2010; Umweltbundesamt, Vienna

The objective of the TABULA project is the development of a harmonised building typology for European countries. Each national building typology consists of a set of residential reference buildings with characteristic energy related properties (envelope areas, U-values, supply system efficiencies).

The main results of the project will be disseminated by a project website with the webtool and National Typology Brochures (for each partner in their national language). Apart from publishing the building data and statistics, the website serves as an online demonstration tool ("webtool"): For each reference building an online calculation feature will show the possible energy savings which can be obtained by refurbishment measures of different quality. The brochures offer the same information, although being presented in a different manner: the webtool uses European standards and the English language whereas the national brochures describe the national standards in the respective national language.

The published data can be used by experts from all European countries for the assessment of national building stocks, for cross-country comparisons or for scenario calculations. In the long run, the national building typologies can be used for forecasting and evaluating the energy savings and the carbon dioxide emission reduction potential for each European country. Furthermore, a possible expansion to non-participating European Member States would enable an EU-wide evaluation and monitoring.

2 Content of this report

This report describes the typology, its development, the used data sources and calculation methods and the additional activities. Five basic activities were necessary to develop the national typologies:

- **Analysis of building data**
- **Analysis of supply system data**
- **Analysis of data on the frequency of buildings and system types**
- **Energy balances and energy saving measures**: Energy balance calculations according to the respective national Energy Performance Certification Procedures and energy savings by refurbishment measures in the two categories “standard” and “advanced”
- **Additional Activities: development of a non-residential building typology**

As there was no Austria national building typology on hand before, the Austrian Energy Agency had to combine several existing data sources. Regarding the Austrian CO_2-emission reducing targets, the non-residential building sector also has an enormous impact. Therefore an enlargement of the Austrian Typology towards non-residential buildings was intended [see Annex 1]. While substantial data on the residential building stock is existing, there is a severe lack of data regarding non-residential buildings.

The Austrian reference buildings project combines the top-down and the bottom-up approach. The top-down approach means that diverse existing information on the Austrian building stock have been combined and resulted in a draft building typology. In the process of collecting information, lack of information was detected and missing data were added in the course of the project. Bottom-up approach means that building data collected via Energy performance certificate database ZEUS have been used to verify the draft building typology.

3 The general approach and objective of the project

The main activities of the project are:

- **Development of a harmonised structure for national building typologies**
- **Analysis of the specific building type data and frequencies**
- **Development of national typology brochures**
- **Development and utilisation of a website which serves as a data source for scenario calculation activities**

During the first project phase, information about existing national building typologies has been collected and analysed regarding their structure, data sources and application ranges. Based on this survey, a harmonised approach for a structure of national typologies was developed according to the main project objectives:

- to offer well-structured basic data for experts who want to analyse the residential building stock and to carry out scenario analyses
- to offer a clear and comprehensible data presentation easy to use for initial energy advice (e.g. by energy consultants) and understandable for the public (e.g. house owners)

This common typology structure has been developed jointly by the whole project team. Later it has been filled with data (e.g. frequency of building types, typical values of envelope areas, U-values, g-values, efficiency of heat supply systems, etc.) using different kinds of data sources [see chapter 4.2]. The results are documented in the National Typology Brochure (for each country in the respective national language).

The second task was to bring all results together by means of the typology webtool. The webtool can be used by energy experts and by the public as an information source about

- typical indicators describing each building and heat system type
- the frequency of building types and heating system types in the national respective housing stock.

Furthermore, analysis were carried out regarding typology approaches in countries not participating in the project[2]. The needs of the target groups have been analysed and discussed according to the existing experiences of the participating project partners. The partners also have implemented national advisory groups, comprising further experts in the fields of (regional) legislation, energy advice, building refurbishment, heat supply systems, or similar [details see 4.2.6].

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[2] Analysis information via internet and telephone interviews of experts from other countries; Austria's "external partner" in the project is Hungary (contact project partner: http://www.energiakozpont.hu/)

Based on the results of the analysis, the project team has found an agreement on the common building typology structure. The **building typology structure** consists of:

- A "**building matrix**" providing an overview of all building types and giving numbers for the frequency of each building type in the national building stock.

  The building types are defined by building size and erection period. The following **four building categories** were defined by the consortium:

  - SFH – single-family houses
  - TH – terraced houses
  - MFH – multi-family houses
  - AB – appartment blocks

  Furthermore each partner defined construction periods according to architectural history and available data. For Austria, **seven construction periods** have been defined on national level [see chapter 4.1]. This results in a building matrix **of 28 basic model buildings** on national level.

- "**Sub-typologies**" for building elements ("wall typology", "roof typology" etc.).

The typology does not only describe the buildings and heat supply systems as they are, but also delivers information about energy saving measures and energy saving potentials:

- heat demand for space heating
- delivered energy demand for space heating, hot water per energy carrier
- primary energy demand for the above mentioned utilisations
- carbon dioxide emissions for the above mentioned utilisations

During the data collection on national level, each partner used data definitions according to the respective national regulations. Since the national implementations of the CEN standards, the calculation of the energy demand or energy saving potentials differ in many points (internal, central or external dimensions, U-values including or not in-cluding reduction factors, gross or net calorific value for fuels). Therefore the consortium had to agree on a homogeneous definition of a harmonised calculation approach. These definitions are to be found in the Excel-Workbook[3].

[3] Download available on http://www.building-typology.eu/tabula-concept.html

4 The Austrian reference buildings

When the project started in May 2009, in Austria there was no common typology existing. The main work of the Austrian Energy Agency was to find the most helpful information out of different sources and to put this information together, so as to get an overall view of the national building stock. The most important information needed is:

- available number of buildings/square meters of floor area related to buildings size and erection periods, and
- Information about Austrian architecture and building technologies (typical materials and heating supply systems used in the different erection periods).

4.1 Basic parameters

The two basic parameters – building size and construction period – compose the two principal axes of the matrix of the building typology and are the basis of the TABULA buildings.

- The **building size** is defined in the four categories:
  - SFH Single-family houses
  - TH Terraced houses
  - MFH Multi-family houses
  - AB Apartment blocks

- The **construction periods** depend on the national (architectural) history and/or national statistics. In Austria it is a combination of both. In the Austrian Typology (in the webtool as well as in the national brochure) the following construction periods (according to the "Gebäude- und Wohnungszählung" from Statistik Austria)[4] are used:
  - I up to 1918
  - II 1919–44
  - III 1945–60
  - IV 1961–80
  - V 1981–90
  - VI 1991–00
  - VII 2001–10

The TABULA brochure presents 28 basic buildings, based on the Austrian reference climate, with respective possible refurbishment measures. The TABULA webtool provides 56 build-

[4] English: Austrian statistical micro- census

ings, considering two climatic zones “generic” and ”’mountain”, with its possible refurbishment measures.

4.2 The sources to develop reference buildings

In order to find buildings, diverse literature sources, data of an Energy performance certificate database, as well as input from experts during presentations and workshops were used. The next chapter gives an overview of the Austrian sources used to find the reference buildings.

4.2.1 Literature used

In Austria, there exist many sources regarding special parts of the architectural history, as well as general information about the national building stock. In general, the information within these sources is quite imprecise regarding the needed detailed information (about e. g. U-values, thickness of layers). The main information and default values used during the project were taken out of the following sources:

- „Leitfaden Energietechnisches Verhalten von Gebäuden“, April 2007
- „Leitfaden zum Umgang mit Energieeffizienz und weiteren Nachhaltigkeitsparametern in der Immobilienwertermittlung“, Februar 2010
- „Atlas Bauen im Bestand”, Hannover 2008, Institut für Bauforschung e.V.
- „Handbuch für Energieberater“, 1994; „Altbaukonstruktionen Musteraufbauten“, Mai 2009, Energieberatung.

Table 1: shows the average values for different parameters in the construction periods I to VII.

Construction period	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**
	-1918	1919-44	1945-60	1961-80	1980-90	1991-00	2001-10
SFH Single-family house							
Living area [m²]	125-155	110-140	110-140	125-155	140-170	145-175	145-175
Heating demand [kWh/m²a]	180-300	200-370	160-380	145-280	100-190	80-130	10-100
U-value [W/(m²K)]	1.0-1.8	1.1-1.45	1.0-1.2	0.6-0.85	0.35-0.8	0.3-0.7	0.2-0.6
MFH Multi-family house/ TH Terraced house							
Living area [m²]	400-800	280-680	280-680	400-800	400-800	350-750	350-750
Heating demand [kWh/m²a]	130-230	140-270	150-270	100-205	80-140	60-100	10-80
U-value [W/(m²K)]	1.0-1.8	1.1-1.45	1.0-1.2	0.6-0.85	0.35-0.8	0.3-0.7	0.2-0.6
AB Apartment blocks							
Living area [m²]	>800	>700	>700	>800	>800	>800	>800
Heating demand [kWh/m²a]	120-220	130-260	130-260	90-190	70-130	50-100	10-80
U-value [W/(m²K)]	0.9-1.7	1.0-1.4	0.9-1.1	0.5-0.8	0.35-0.75	0.3-0.7	0.2-0.6

4.2.2 The EPC database ZEUS

In Austria, first of all in the Province of Salzburg, an Energy performance certificate database called ZEUS has been established to handle the housing subsidy data flow. Meanwhile it is also used by the Provinces Carinthia and Styria, and there has also been established a national port for non residential buildings, called ImmoZEUS.

As in Austria the housing subsidy scheme lies in the responsibility of the federal provinces, the requirements to obtain a building permission or housing subsidy varies. The Energy performance certificate was first introduced in 2000 in the Provinces to gain subsidy schemes for new homes. It contains the description of the thermal building envelope: the configuration of the layers is described, the area is named and the thermal characteristics are documented via U-values. Meanwhile the number of data stored was enlarged, according to the implementation of EPBD. The basis for the calculation of EPCs are the national standards “ÖNORM B 5055 – B 5059” where the thermal characteristics are described and the calculation process is standardised.

At the moment there are about 40,000 EPCs saved in the ZEUS databases, 60% of them concerning new buildings and 40% reconstructed buildings. As a matter of fact, the biggest lack of information concerns the technical information: The technical data for heating and domestic hot water often is not available (mainly due to the fact that the older subsidy schemes did not always require a description of the technical equipment, but only the thermal envelope).

With the software company “gizmocraft” (owner of the source code of ZEUS) and the Provinces of Salzburg, Carinthia and Styria, the needed information of the model buildings for the TABULA categories were analysed. Table 2 shows the number of analysed EPCs based on the ZEUS databases, to get an overview of how many EPCs are stored in the single categories:

Table 2: Number of analysed EPCs to establish representative reference buildings [status 2010]

Construction period	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**
	-1918	1919-44	1945-60	1961-80	1980-90	1991-00	2001-10
SFH Single-family house							
Analysed EPCs	267	212	867	2315	563	267	4470
TH Terraced house							
Analysed EPCs	7	21	58	147	101	32	336
MFH Multi-family house							
Analysed EPCs	184	165	413	1277	213	90	358
AB Apartment blocks							
Analysed EPCs	37	41	140	664	117	124	207

The average values taken out of literature [see Table 1] were used to select one typical building for each typology out of the database. That means, the average living area and the average data regarding the thermal envelope (heating demand and U-values) were calculated and the most suitable building was declared as reference building to represent the building typology. Thus, the 28 national model buildings for the TABULA brochure and the 56 model buildings for the European webtool are finally represented by real, existing “average” buildings taken out of the energy certificate database.

4.2.3 Evaluation process

Austrian EPCs calculation is carried out by several software programs. EPCs are uploaded to ZEUS by using a predefined XML format. To collect this data, three files per EPC are stored: XML, PDF and the sourcefile. PDFs keep most of the data including graphics. PDFs are the only document handed over to clients.

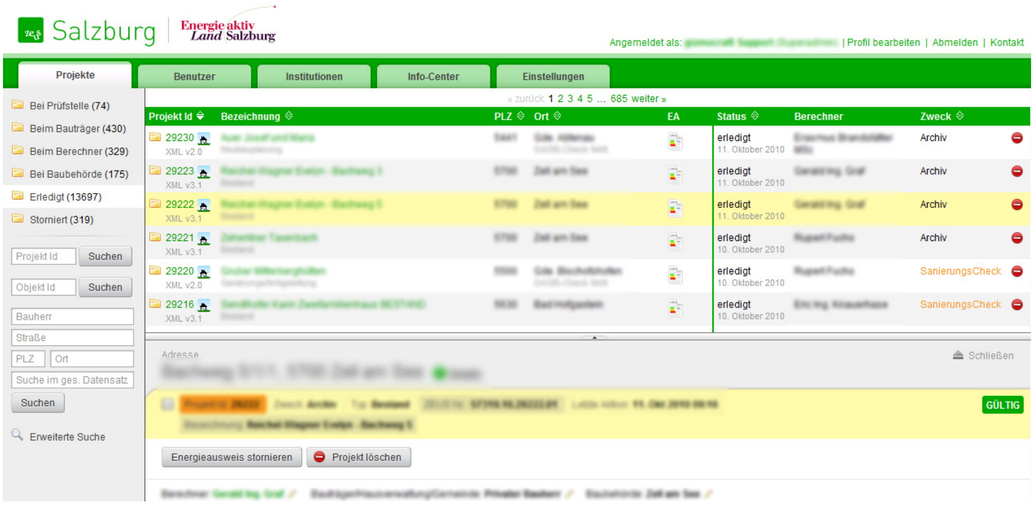


Figure 2: Screenshot of ZEUS online database[5]

In all, 22.000 EPCs from 2003 to 2010 were analysed. The data evaluation method consisted of the following steps:

- **Retrieve existing data stock**
  All EPC data stored via XML within ZEUS have been exported and made anonymous.

- **Prepare existing data stock**
  The EPC raw data has been analysed based on the predefined average values (taken out of literature sources). Sample categorizations regarding the heating energy demand (HWB), gross floor area (GFA) and U-value were made in order to qualify all possible EPCs.

- **Refine data stock**
  Creation dates of EPCs range from 2007 to 2010 because of the usage of comparable data standards for this time period (comparable XML versions).
  EPCs at this stage count to 18.500.

[5] For more details of ZEUS and XML standardization see http://www.energieausweise.net.

- **Consolidate data stock**
  At the data consolidation stage buildings have been identified where EPCs before and after the refurbishment of the building are available. Sample IDs were evaluated and XML data were further investigated for quality purposes.
  EPCs sample count to 70

- **Identify relevant IDs of EPCs for further investigations**
  Identification of relevant buildings has been based on the representative model buildings. Final EPCs count to 52

- **Extract all Data of identified EPC IDs used in the XML data structure and PDF**
  All data of the identified relevant buildings have been extracted. As mentioned, some data information, especially the exact data of the building elements, can only be taken out of the stored PDF file. So PDFs were made anonymous and data of building elements were extracted.

ZEUS database is implemented in three of nine provinces of Austria. To put an Austrian-wide standardized and qualified EPC data collection in place, ZEUS could be rolled out to the other federal provinces as well.

4.2.4 Excel data processing

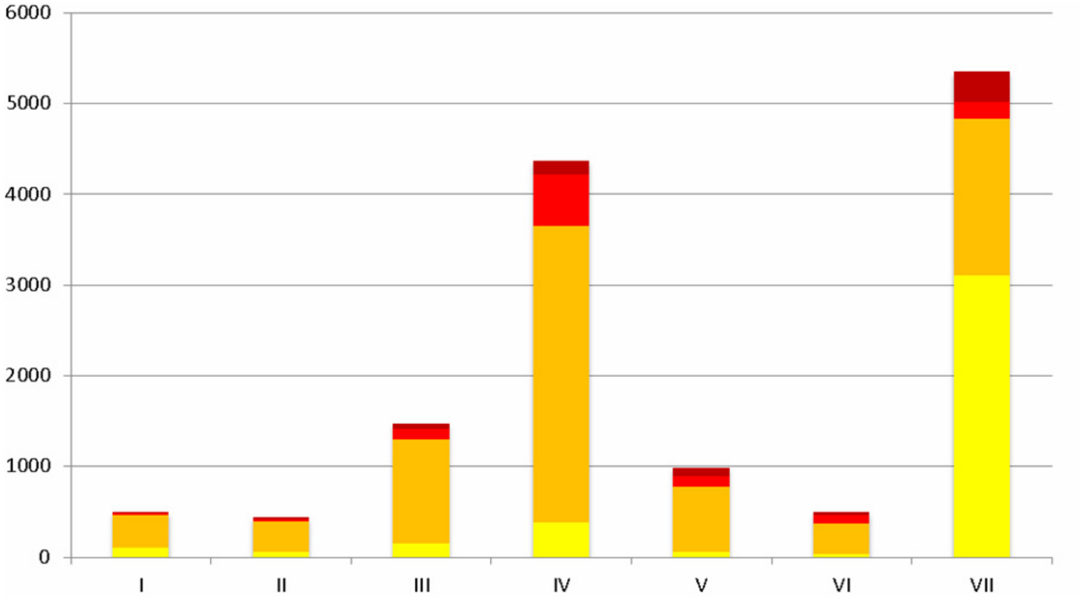
For categorization purposes, these EPCs had to be tagged by categorization values in order to make statistical calculations possible. To assign tags like “*class of year of construction”* and “*class of building”* a configuration table has been set up. Based on these tags, statical calculations have been carried out for residential and non residential buildings. For that, Excel pivot table functions were used.

	A	B	C	D	E
1	Nutzungszone	(Alle)			
2	XML-Version	(Alle)			
3	Land	(Alle)			
4	Hilfsfeld HWB Standort	(Mehrere Elemente)			
5	Gebäudeklasse	NWG			
6					
7		**Werte**			
8	**Zeilenbeschriftungen**	**Anzahl von ID**	**Mittelwert von HWB Standortklima spezifisch [kWh/m²a]**	**Mittelwert von Bruttogrundfläche [m²]**	**Mittelwert von Mittlerer U-Wert [W/m²K]**
9	I	78	142,649924	944,8012821	0,919051282
10	II	20	115,881698	1316,2395	0,6295
11	III	86	137,8905456	916,0218605	0,728686047
12	IV	231	128,8561863	1489,169004	0,715995671
13	V	90	94,52259567	2647,552444	0,533755556
14	VI	58	97,21738166	1101,884138	0,513637931
15	VII	153	62,4801975	1056,179935	0,342732026
16	**Gesamtergebnis**	716	**110,0192821**	**1377,904665**	**0,618163408**
17					

Figure 3: Example of excel pivot table calculation: average values for heating demand, gross building area and of U-values.

4.2.5 Statistical results of ZEUS data export

The following graphics show statical results of the data export.



- terraced houses
- apartment blocks
- multifamily houses
- singlefamily houses

Figure 4: Example of excel pivot table calculation: quantities of residential buildings stored in the ZEUS EPC database per construction period and building category

Table 3: Comparison of heating demand [kWh/m²a] of analysed ZEUS EPC data with literature data

Average heating demand [kWh/m²a]	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**
	-1918	1919-44	1945-60	1961-80	1980-90	1991-00	2001-10
	SFH Single-family house						
ZEUS	186	251	216	153	96	95	70
Literature	180-300	200-370	160-380	145-280	90-190	80-130	10-100
TH Terraced house							
ZEUS	257*	112*	171	145	110	93*	53
Literature	130-230	140-270	150-270	100-205	80-140	60-100	10-80
MFH Multi-family house							
ZEUS	154	154	160	154	125	97	70
Literature	130-230	140-270	150-270	100-205	80-140	60-100	10-80
AB Apartment blocks							
ZEUS	119*	105*	92	86	81	68	51
Literature	120-220	130-260	130-260	90-190	70-130	50-100	10-80

* no statistical validity – less than 50 EPCs analysed

The following graphs show comparisons of the average heating demand (green bar) of the different construction periods taken out of the ZEUS EPC database with the range of literature data. It can be asserted that the database values correspond with the average values taken out of literature but change their emphasis within this range.

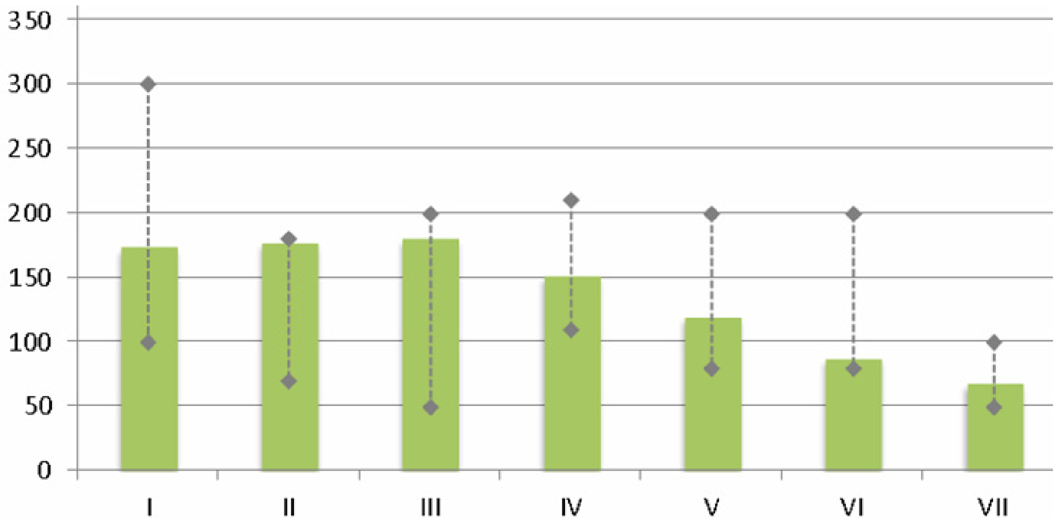


Figure 5: Example of excel pivot table calculation: comparison of heating demand [kWh/m²a] of analysed ZEUS building stock data (green bar) per construction period – including all building categories (SFH, TH, MFH, AB) – with literature data.

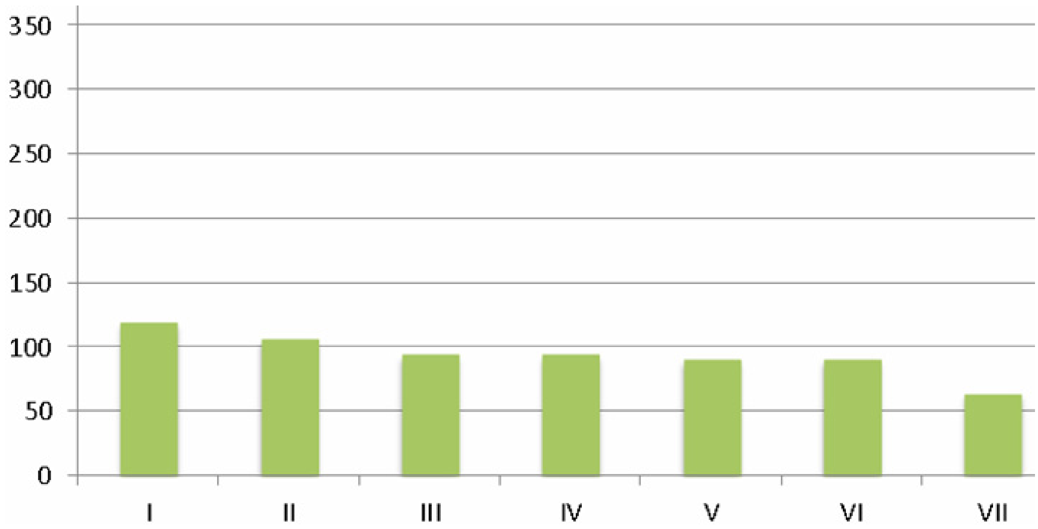


Figure 6: Example of excel pivot table calculation: heating demand [kWh/m²a] of analysed ZEUS refurbished buildings data (green bar) including all building categories (SFH, TH, MFH, AB).

Furthermore a comparison of the analysed average U-values (green bar) of the EPC database has been contrasted to the range of literature data.

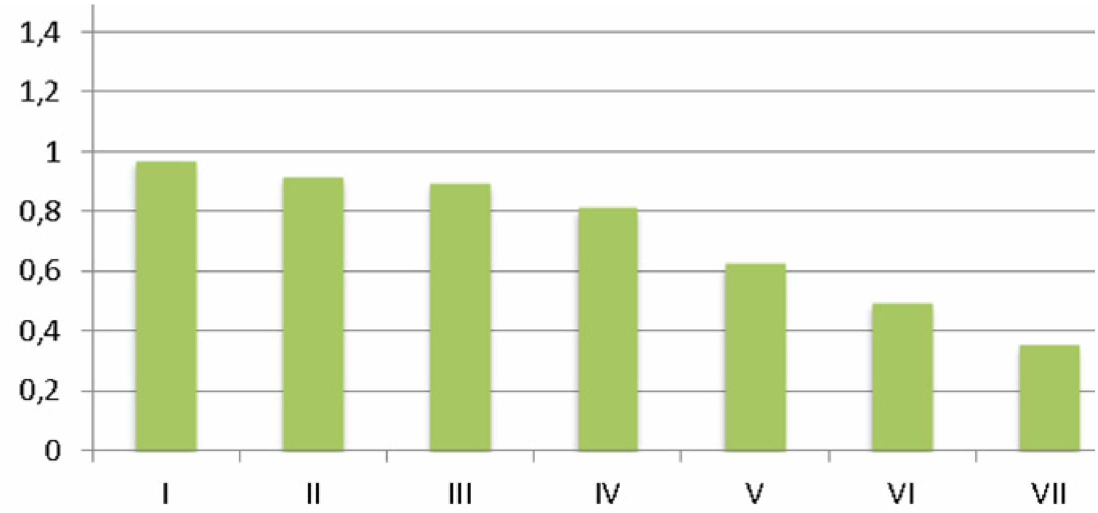


Figure 7: Residential building: average of U-values per class of building [W/m²K]

It can be asserted that the average U-values of the database are generally lying in the lower range compared to the literature values. This is because the ZEUS-stored EPCs represent real buildings, numerous of which have already been refurbished in the past, therefore showing better (=lower) U-values.

4.2.6 Additional information

In case that there was still missing information regarding the reference buildings, a third information ”source” was deployed: the ”national advisory group – NAG”. In Austria, this NAG consists of 31 members of the regional energy agencies, local authorities, energy advisors and further experts in the buildings and/or technical systems sector.

A first step was to inform the energy experts in Austria that there was a project under way aiming at the creation of a national building typology. Therefore, in the so-called KLEA-meeting (cooperation of provinces and energy agencies) in November 2009, the Austrian Energy Agency held a presentation on the general approach, the aims and the necessary steps to install a building typology in Austria in the frame of the TABULA project. The regional energy advisors were involved within the annual national “klima:aktiv” (climate:active) energy consultants meeting. “Klima:aktiv” energy consultants are especially trained in the criteria to get a commendation of the programme.

In the “klima:aktiv Energieberater Workshop” in November 2010, the developed typology and its system data were presented and revised. After finishing the first version of the national TABULA brochure in May 2011, feedback from the national advisory group experts was taken into account for updating the brochure. The mentioned presentations and workshops were used to get additional information, either regarding the structure of the brochure, or information missing with regard to some special reference building.

4.3 Definition of the building matrix

4.3.1 Frequencies

The national statistic “Gebäude- und Wohnungszählung” (dwelling and building census) by the Austrian Statistical Office contains the number of buildings and the living area sorted according to building periods. This census was started in 1981 and is carried out every ten years.

Table 4: National statistic “Gebäude- und Wohnungszählung” (dwelling and building census) 2001 considering residential and non-residential buildings in their construction periods and building size (number of dwellings).

	number* of dwellings…						
	all…		in residential buildings …				in non-residential buildings
	total number of dwellings	thereof principal residence	1or 2 dwellings	3 to 10 dwellings	11 and more dwellings	flat-sharing communities	
AUSTRIA	**3,863,262**	**3,315,347**	**1,809,380**	**791,584**	**1,134,782**	**21,663**	**105,853**
living space area of princi-pals *in 1000 m²*		*299,636.0*	*176,050.2*	*51,007.2*	*64,806.3*	*520.4*	*7,251.9*
construction period							
before 1919	764,747	618,452	283,836	182,801	263,321	2,510	32,279
1919 to 1944	333,156	284,664	149,805	95,328	80,071	342	7,610
1945 to 1960	475,654	415,935	234,496	103,377	125,066	677	12,038
1961to 1980	1,243,436	1,070,168	593,916	182,546	426,784	8,411	31,779
1981 to 1990	486,402	433,067	274,528	87,256	108,603	3,303	12,712
1991 to 2000	559,867	493,061	272,799	140,276	130,937	6,420	9,435

* The figures in the table are representing dwellings except in the grey-highlited line which shows the living space area in 1,000 square-meters. These inside-measured metres had to be multiplied by 1.2[6] to get the external dimension.

As the national statistics make no difference between multi-family houses and terraced-houses, there is no detailed information available and the category TH is therefore included in MFH. So for the Austrian typology, the frequency of buildings and square metres can only be displayed for three building sizes:

- Single-family houses: the numbers are taken out of “residential buildings with 1 to 2 dwellings”

[6] According to Austrian guideline „Leitfaden Energietechnisches VeTHalten von Gebäuden“; Austrian Institute for Construction Engineering (2007)

- Multi-family houses: the numbers are taken out of “residential buildings with 3 to 10 dwellings”
- Apartment blocks: the numbers are taken out of “residential buildings with more than 11 dwellings”

The number of residential buildings for each building size and the total area of living space were taken out of an actualised evaluation of the statistical data, corresponding to the TABULA typology, including all building periods until december 2010.

Table 5: The classification of the Austrian building stock according to the TABULA requirements: number of residential buildings and square metres (living area in m²) on national level

Construction period		**Building size**		
		SFH	**MFH**	**AB**
-1919	number of res.-bui.	235,723	36,025	15,228
	Living area (m²)	30,583,052	14,145,992	16,932,197
1919-1944	number of res.-bui.	129,086	18,550	5,025
	Living area (m²)	14,350,763	6,161,368	4,318,376
1945-1960	number of res.-bui.	194,442	19,868	7,727
	Living area (m²)	22,944,091	7,001,308	7,317,536
1961-1980	number of res.-bui.	489,397	37,104	21,750
	Living area (m²)	65,375,704	14,739,613	28,912,454
1981-1990	number of res.-bui.	246,757	17,592	6,058
	Living area (m²)	33,945,697	7,728,972	8,345,633
1991-2000	number of res.-bui.	159,118	16,821	4,131
	Living area (m²)	22,186,226	7,389,169	4,777,708
since 2001	number of res.-bui.	173,525	18,405	4,636
	Living area (m²)	25,978,316	7,985,746	5,620,676
Missing data *	number of res.-bui.	116,063	5,617	2,617
	Living area (m²)	13,624,483	2,541,389	3,920,095

*The categorie “missing data” contains buildings of construction periods which are not relatable due to a gap in the data acquisition. Nevertheless, it is assumed that the majority of the buildings are part of the construction period 1991–2000.

4.3.2 Definition of the geometrical and energetic characteristics

Beside the two basic parameters, the energy performance of buildings is determined by a number of other parameters and factors including construction elements, geometry of the building, environment, age and kind of the energy-technical systems, as well as already implemented measures.

For each building type one building has been selected representative for all buildings of this class. As "representative" apply buildings which in terms of their U-value, their gross floor area, their space heating and domestic hot water systems[7] represent average buildings. For this, real buildings with Energy performance certificates calculated according to the national OIB-RL 6 has been selected out of the energy certificate database ZEUS.

The energetic building characteristics are calculated in form of datasets which on the one hand include general information about the building (thermal properties and energy systems) and on the other hand other specific information, such as the U-values of the building elements and efficiency indicators of the heating and domestic hot water systems.

Over the decades, the changes of construction principles and building materials have resulted in different heat pass coefficients and transmission heat losses. The amount of losses through the elements of the thermal envelope, i.e. roof, ceiling, wall, window and floor, significantly depends on the year of construction as well as on the building size and geometry. The lack of thermal isolation in the 1960ies and 70ies e.g. is manifested in the building stock of today. This fact has been taken into consideration in the selection of model buildings, in case that in some of them refurbishment measures had been carried out already.

4.3.3 Definition of the heating system typology

The total energy efficiency depends on the type of heat source as well as on the distribution and storage systems for space heating and domestic hot water. In the early nineteenth century, the main heaters were cockle stoves fired with wood or coal. In many houses there was only one stove situated in the kitchen and one in the living room. Later sometimes additional stoves were installed. In the cities stoves were installed per dwelling or later per storey. Often these were wood-fired systems, later more and more oil or gas has been used.

In the last decades, the energy system technologies improved significantly. Many of the technical facilities have been renovated in recent years or have been completely replaced. Since 1994, new systems have been installed: low-temperature or condensing boilers with a higher efficiency. The energy carriers vary: pellets, gas and oil. Also the district heating grids spreaded, so the amount of households with district heating increased. In the past ten years the installation of alternative systems like heat pumps also increased [see table 10]. Therefore a correlation of the supply system with the construction year of the building cannot be expected. This fact has been taken into consideration in the selection of model buildings.[8]

The requirements for the energy use for heating systems is defined in the Austrian standard "ÖNORM H 5056" [9]. The national distribution of heating system and energy carrier per typology were defined on the basis of the microcensus[10] [see following table]. It represents the current status of installed systems in the building stock.

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7 The specifications should be seen as indicative and may vary from individual buildings.

8 The buildings shown in the brochure represent sample buildings per typology. For a national evaluation of the building stock, for example in terms of the final energy consumption, diverse heating systems and energy carriers have to be taken into consideration within a typology.

9 Gesamtenergieffizienz von Gebäuden – Heiztechnik-Energiebedarf: ÖNORM H 5056 (2010), Tabelle 37; Austrian Standards Institute

10 „Gebäude- und Wohnungszählung 2001", Wien: Statistik Austria 2001; Tabellen B3 und B13a-c

Table 6: Current distribution of heating systems and energy carriers in the Austrian building stock

	SFH		MFH/TH		AB	
	heating system and energy carrier	**%**	**heating system and energy carrier**	**%**	**heating system and energy carrier**	**%**
before 1919	gas central heating, standard boiler	28	electric direct heating	17	electric direct heating	17
	wood central heating	42	gas central heating, standard boiler	59	gas central heating, standard boiler	59
	oil central heating, standard boiler	30	gas central heating, standard boiler	24	gas central heating, standard boiler	24
1919– 1944	gas central heating, standard boiler	40	electric direct heating	18	single stoves oil	21
	wood central heating	24	district heating	46	district heating	44
	oil central heating, standard boiler	36	gas central heating, standard boiler	36	gas central heating, standard boiler	35
1945– 1960	gas central heating, standard boiler	29	electric direct heating	25	electric direct heating	25
	wood central heating	46	gas central heating, standard boiler	34	single stoves oil	34
	oil central heating, standard boiler	25	gas central heating, standard boiler	41	gas central heating, standard boiler	41
1961– 1980	gas central heating, standard boiler	32	district heating	63	district heating	63
	wood central heating	24	oil central heating, standard boiler	19	oil central heating, standard boiler	19
	oil central heating, standard boiler	44	gas central heating, standard boiler	18	gas central heating, standard boiler	18
1981–1990	gas central heating, standard boiler	20	electric direct heating	21	electric direct heating	21
	pellets central heat-ing	26	district heating	53	district heating	53
	oil central heating, standard boiler	53	gas central heating, standard boiler	26	gas central heating, standard boiler	26
1991– 2000	gas central heating, condensing boiler	31	gas central heating, condensing boiler	72	district heating	72
	pellets central heat-ing	17	district heating	14	electric direct heating	14
	oil central heating, standard boiler	53	gas central heating, standard boiler	14	gas central heating, standard boiler	14
2000– 2010	electric direct heating	40	gas central heating, condensing boiler	25	gas central heating, condensing boiler	25
	pellets central heat-ing	20	district heating	50	district heating	50
	oil central heating, condensing boiler	40	gas central heating, standard boiler	25	gas central heating, standard boiler	25

4.3.4 Definition of the domestic hot water (dhw) typology

In the national calculation software programs to calculate the EPCs, a default value for domestic hot water is used. For residential houses this means 12.78 kWh/m²a. Additionally, it is not documented in detail in the national microcensus what kind of dhw system is installed in the buidings. For the losses of the domestic hot water system and the storage system, the necessary data is taken out of the guideline "Gesamtenergieffizienz von Gebäuden – Heiztechnik-Energiebedarf: ÖNORM H 5056" 2010.

4.3.5 Limitations of the typology

As noted earlier, the selected buildings are considered as representative in terms of their heating demand, their U-values, their gross floor area and their space heating and domestic hot water systems. The building data are to be used as guideline values, to be able to make general statements about the national building stock. The detailed values however vary from individual buildings.

The building typology provides also an overview of the building types and its refurbishment potentials. For the specific refurbishment planning of a building, a professional must be consulted in any case. Within the klima:aktiv awareness programm, contacts of numerous energy consultans are listed, to facilitate building owners the access to professionals.[11]

[11] "klima:aktiv" refurbishment consultancy: www.maps.klimaaktiv.at.

4.4 The refurbishment requirements

The refurbishment measures are defined on two levels: a "standard refurbishment" according to the guideline no. 6 of the Austrian Institute of Civil Engineering[12] and an advanced stage defined according to the requirements of the national climate protection programme "klima:aktiv".[13]

4.4.1.1 The minimum requirements of the national standard

The OIB guideline no. 6 describes the following minimum requirements for the refurbishment of a residential building:

- Minimum U-values [W/(m²K)] of the thermal envelope:
  - Ceiling / Roof = 0.20
  - External Walls = 0.35
  - Windows = 1.40
  - Floor / Cellar ceiling = 0.40

If the building undergoes major renovation, additionally to the U-values mentioned above, the energy demand [HWB] has to be restricted according to the following formula:

$$HWB_{GFA,Ref,max} = 25.0 \text{ x } (1+2.5 / l_c)\text{; absolute maximum} = 87.5 \text{ kWh/m²a}$$

The value l_c represents the geometrical quality of the building and is calculated by dividing the conditioned volume [m³] by the conditioned gross-floor area [m²]

Example: Heated volume = 480m³, heated gross-floor area = 135m³ > l_c = 480/135 = 3.55 that means the maximum HWB is: 25.0 x (1 + 2.5 / 3.55) = 42.60 kWh/m²a

- Also the final energy demand [EEB] has to be calculated and has to be lower than a reference final energy demand. This is defined by the following calculation:

$$EEB_{GFA} \leq (HWB_{GFA,max,Ref} \text{ x } (HGT_{location} / 3{,}400)) + WWWB_{GFA} + 1.05 \text{ x } HTEB_{GFA,Ref}$$

4.4.1.2 The minimum requirements according to klima:aktiv

The main focus of the climate protection programme is set on the energetic performance of the building. Additionally to the required minimum U-values and maximum energy demands, it includes issues of the planning process itself, such as the use of ecological building components and the user comfort.

[12] OIB Richtlinie 6 "Energieeinsparung und Wärmeschutz", OIB 300.6-038/07

[13] http://www.klimaaktiv.at/article/articleview/75401/1/27218/

The declaration criteria are divided into ”must-achieve” and ”can-achieve” criteria to collect the points per category needed to get the award. For the TABULA project only the must-achieve criteria were used (mainly because the can-achieve criteria require detailed calculations/information that cannot be generalised) [14].

These energetic must-achieve requirements used for the advanced stage refurbishment in the national typology brochures, are defined as follows:

- Heating demand after refurbishment of residential buildings

  $HWB_{GFA, RB,Ref} \leq 50$ kWh/m^{2}a for building with ratio ≥ 0.8 (SFH, TH, MFH)

  $HWB_{GFA, RB, Ref} \leq 30$ kWh/m^{2}a for building with ratio ≥ 0.2 (AB)

- CO_2-emissions ≤ 30 kg/m²BGFa

The following environmental, urban and comfort factors also belong to the “must-achieve” criteria, they were however not included into the typology:

- Proof of summer efficiency as per OIB RL 6
- Air-tight building envelope: $n_{50} \leq 3.0\ h^{-1}$
- Thermal-bridge-optimized building envelope – calculative and graphic
- Construction ecologically optimized and free of harmful substances: HFC-and PVC-free wall and ceiling paintings
- Simplified calculation of life cycle costs
- Verification of the densification possibilities in the urban space
- 1 bicycle space per 40m² (SFH) or 75m² (MFH/TH/AP) living space area

[14] The detailed criteria catalogue can be found via http://www.klimaaktiv.at/article/articleview/75401/1/27218/ (in German).

4.5 TABULA typology-based scenario for national final energy demand and national CO_2 emission reduction potentials

A national building typology can be used for the illustration of the final energy demand of the building stock of a country. To this end, apart from the primarily determined building categories and construction periods, additional information about the quantities of the building types, of the heating and domestic hot water systems and energy carriers as well as the already realised refurbishment measures is needed.

The TABULA residential buildings typology exemplarily provides all this kind of information. Thus, by means of the TABULA-typology-based calculation, the **distribution of the national final energy demand per construction period**, **the national final energy consumption** and the **final energy demand reduction potentials** (according to OIB RL 6 standard or climate:active ambitious refurbishment) per building type can be demonstrated [see graphics below].

For carrying out the calculation, the following sources have been used:

- The 28 model buildings of the TABULA typology
- the statistical data “Gebäude- und Wohnungszählung” (dwelling and building census) of Statistik Austria [see chapter 4.3.1]
- the Statistical distribution of heating systems and energy carriers in the Austrian building stock including already refurbished systems as shown in table 13 before.

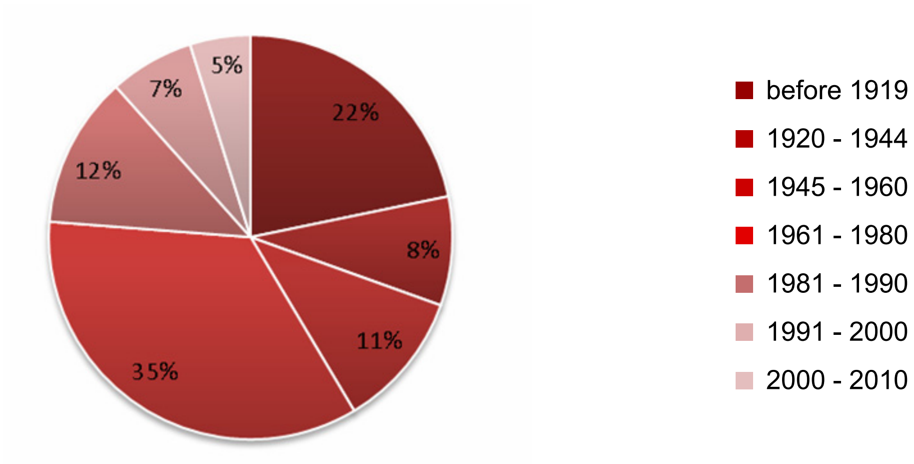

Figure 8: Distribution of the national final energy demand per specific construction period (including all residential building categories)

For the scenario analysis of national final energy saving potentials, the refurbishment of the heating systems had to be defined. So for each of the three statistical most common energy carriers and heating systems, as shown in Table 13, a refurbishment version was assumed [see table below].

Table 7: Distribution of heating systems and energy carriers after refurbishment

	SFH		MFH/TH		AB	
	main heating system and energy carrier	**%**	**main heating system and energy carrier**	**%**	**main heating system and energy carrier**	**%**
before 1919	gas central heating, standard boiler	28	electric direct heating	17	electric direct heating	17
	wood central heating	42	gas central heating, standard boiler	59	gas central heating, standard boiler	59
	oil central heating, standard boiler	30	gas central heating, standard boiler	24	gas central heating, standard boiler	24
1919–1944	gas central heating, standard boiler	40	electric direct heating	18	single stoves oil	21
	wood central heating	24	district heating	46	district heating	44
	oil central heating, standard boiler	36	gas central heating, standard boiler	36	gas central heating, standard boiler	35
1945–1960	gas central heating, standard boiler	29	electric direct heating	25	electric direct heating	25
	wood central heating	46	gas central heating, standard boiler	34	single stoves oil	34
	oil central heating, standard boiler	25	gas central heating, standard boiler	41	gas central heating, standard boiler	41
1961–1980	gas central heating, standard boiler	31	district heating	63	district heating	63
	wood central heating	24	oil central heating, standard boiler	19	oil central heating, standard boiler	19
	oil central heating, standard boiler	44	gas central heating, standard boiler	18	gas central heating, standard boiler	18
1981–1990	gas central heating, standard boiler	20	electric direct heating	21	electric direct heating	21
	pellets central heating	27	district heating	53	district heating	53
	oil central heating, standard boiler	53	gas central heating, standard boiler	26	gas central heating, standard boiler	26
1991–2000	gas central heating, condensing boiler	31	gas central heating, condensing boiler	72	district heating	72
	pellets central heating	17	district heating	14	electric direct heating	14
	oil central heating, standard boiler	53	gas central heating, standard boiler	14	gas central heating, standard boiler	14
2000–2010	electric direct heating	40	gas central heating, condensing boiler	25	gas central heating, condensing boiler	25
	pellets central heating	20	district heating	50	district heating	50
	oil central heating, condensing boiler	40	gas central heating, standard boiler	25	gas central heating, standard boiler	25

Extrapolated to the national level, according to the scenario analysis “standard refurbishment” and “advanced refurbishment”, **final energy saving potentials** can be achieved per type as shown in figure 9. From the 2 million buildings in Austria about 1.5 million count among the category of one- and two-family houses, so there is evidence that the major potential lies in this category.

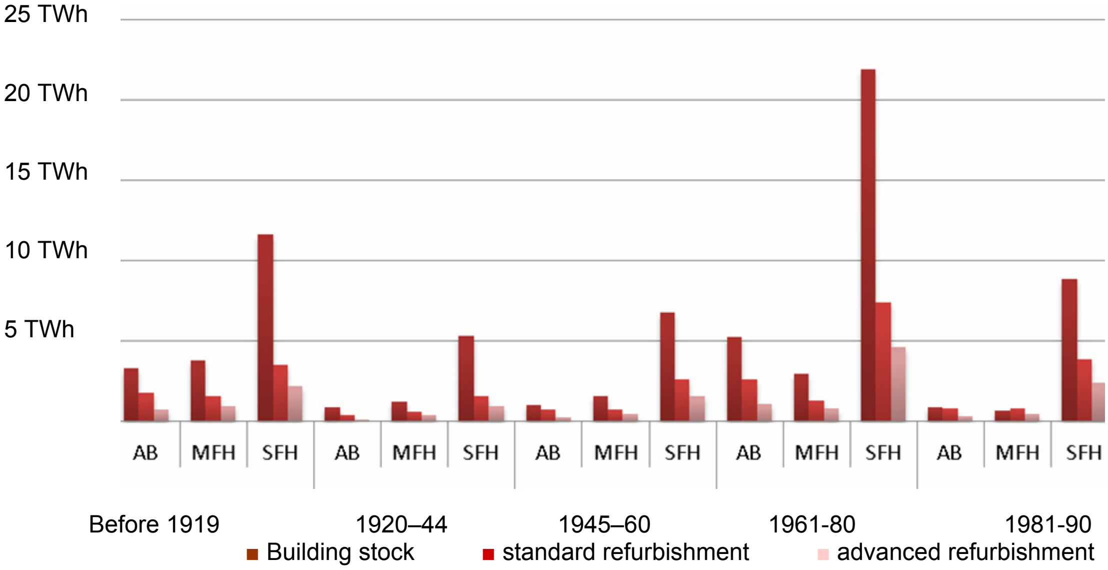

Figure 9: Based on the typology, the scenarios of possible national final energy demand reduction potentials (in TWh) per construction period and building category are generated.

The final energy demand results from TABULA scenario analysis were compared to the national statistical data. On the basis of the TABULA building typology and the statistical model for space heating, domestic hot water and energy carriers, the national final energy demand for Austria reaches **101,636 GWh**.

To convert the theorical calculated final energy demand from TABULA into the practical measured national final energy consumption, the **“servicefactor” 0.65** (compare “Influencing factors of the heating energy consumption in Austria”[15]). The **national final energy consumption** for the sector space heating (187,790 TJ) and domestic hot water (33,640 TJ) results in altogether 221,430 TJ[16] - and converted into GWh - in **61,508 GWh**.

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[15] Source: Skopetz, Harald: „Einflussfaktoren auf den Heizenergieverbrauch in Osterreich“ (“Influencing factors of the heating energy consumption in Austria”), diploma thesis, Institute for electrical systems and energy economy, Technical University Vienna, 2001

[16] Source: Values for domestic homes, 2009, ”Energiebilanzen Österreich 1970–2009” Statistik Austria, („Energy-balances Austria 1970–2009“, Statistic Austria)

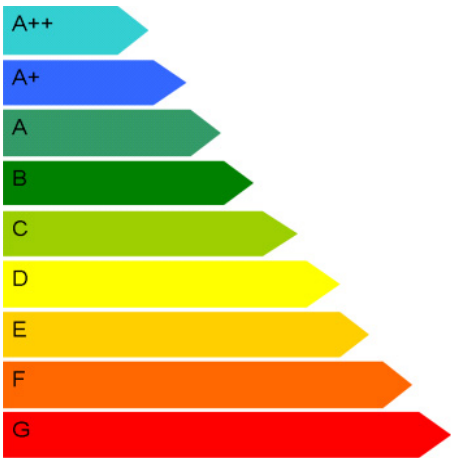
5 EPC calculation standards in Austria

The calculation process in Austria is defined in the national standards called "ÖNORM". The standards index H, numbers 5055 up to 5059 concern the general requirements for energy performance certification calculations, as well as the calculation of energy performance for heating and domestic hot water, ventilation, cooling and lighting (for non-residential buildings), whereas the standards index B, numbers 8110-1 up to 8110-6 deal with the thermal requirements of buildings.

In the beginning of the European standards implementation process, it was the Austrian Institute of Construction Engineering that defined the OIB-RL 6, "guideline no. 6", handling the implementation process by defining common minimum requirements and defining the standards to be used for the calculation of EPCs in Austria. On regional level the implementation of the EPC into the building codes including the minimum requirements, took place in 2009. By adopting OIB-RL 6 into regional law, some Provinces adopted additional requirements into regional law, so the diversity of the nine provincial EPCs is still there.

5.1 The Austrian EPC

The cover page of the EPC presents the efficiency scale showing the so-called "$HWB_{BGF,Ref}$", that is the calculated heating demand of the building [HWB] related to the external dimensions of the building [BGF], in a national reference climate [Ref]. This scale is defined by the ÖNORM H 5055.



Klasse A++:$HWB_{BGF,Ref}$ < 10 kWh/m²a

Klasse A+: $HWB_{BGF,Ref}$ 10-15 kWh/m²a

Klasse A: $HWB_{BGF,Ref}$ 15-25 kWh/m²a

Klasse B: $HWB_{BGF,Ref}$ 25-50 kWh/m²a

Klasse C: $HWB_{BGF,Ref}$ 50-100 kWh/m²a

Klasse D: $HWB_{BGF,Ref}$ 100-150 kWh/m²a

Klasse E: $HWB_{BGF,Ref}$ 150-200 kWh/m²a

Klasse F: $HWB_{BGF,Ref}$ 200-250 kWh/m²a

Klasse G: $HWB_{BGF,Ref}$ > 250 kWh/m²a

Figure 10: The Austrian EPC efficiency scale

The heating demand of the building is calculated by the sum of transmission and ventilation losses compared to the (useful) internal and solar gains. The following figure shows exemplarily such a calculation on a monthly basis.

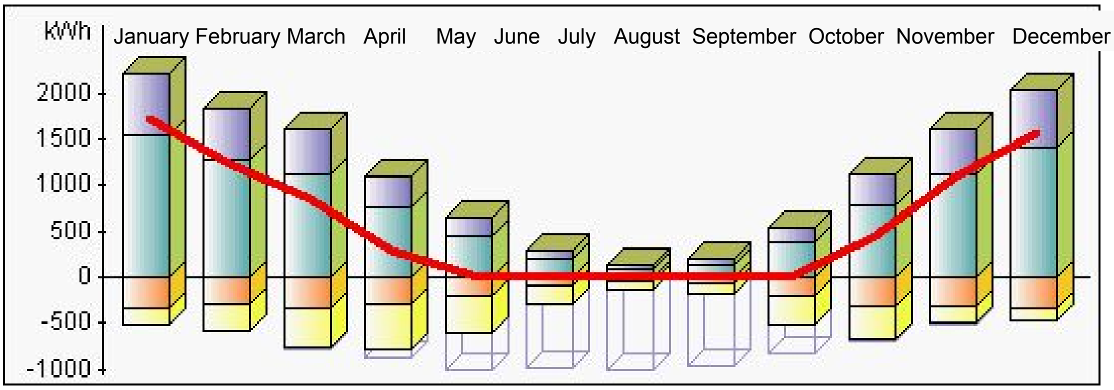


Figure 11: Heating demand – exemplary result of EPC calculation

The violet (upper) boxes show the ventilation losses, the green boxes show the transmission losses. The orange boxes show the useful internal gains and the yellow ones show the useful solar gains. The invisible boxes represent the not-useable gains in the summer months. The red line is the result on monthly basis – the heating demand of the building [HWB].

This heating demand is related to the external dimensions of the building (the gross-floor area) and also referenced to one common reference climate.

5.1.1 The reference climate

It is mainly defined by the solar gains and losses, the internal room temperature to be achieved (20°), the heating temperature barrier (12°) and the number of heating-degree days (3,400). The detailed reference climate conditions are described in the ÖNORM B 8110-5.

5.1.2 National climatic zones

In Austria there are seven climatic zones as shown in the following figure.

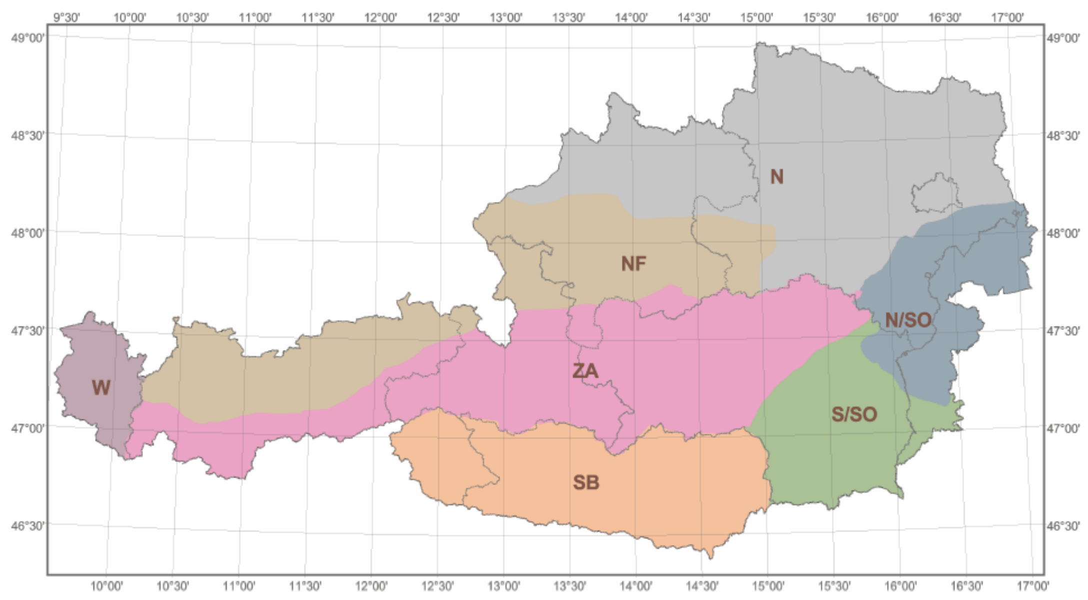


Figure 12: Austria's climatic zones

The seven regions are:

- N: northern zone, out of Foehn[17] regions
- NF: northern, Foehn zone
- ZA: Central Alps
- N/SO: northern south-east
- S/SO: southern south-east
- SB: southern basin landscape

For the calculation of the EPC in Austria, there are two climatic conditions given: on the one hand the location of the respective building and on the other hand the reference climate.

There is a climate-description belonging to the national OIB guideline, where the sealevel, the heat-degree days, the heating-days, the external average temperature and the lowest external temperature, as well as the solar gains (according to the orientation) are listet for about 2,081 towns (per Province, defined by the post-code) in Austria.

For the webtool two regions are used: the first is the national, representing the reference climate. The second is the mountain climate, represented by the ZA climate (see figure above). The mountain climate represents the most inconvenient climatic conditions in Austria (high sea-level, long and cold winters), while the national climate is the more convenient climate. The climatic conditions according to the OIB guideline for these two climatic zones are shown in the following table.

Table 8: The national standardised "Referenzklima" (reference clima) and the mountain climate for one example place named "Kühtai"

zone	ZIP	cityname	sealevel [m]	HDD*$_{12/20}$	heating days$_{12}$ [d]	θ_e [°C]	θ_{ne} [°C]	I_S [kWh/m²a]	$I_{E/W}$ [kWh/m²a]	I_N [kWh/m²a]
mountain	6183	e.g. Kühtai	1966	6689	342	0.44	-20	944	702	417
national		Reference climate	172	3400	212	9.78	-12	819	659	402

*HDD Heating degree days

17 The basic meteorological processes behind this Conceptual Model are related to orographically forced rising and sinking, and associated dry and wet adiabatic cooling and warming. The basic condition leading to a Foehn process is a flow perpendicular to a mountain range.

6 Overview of the buildings

The following figure shows a screenshot of the Austrian reference buildings in form of a matrix.

Figure 13: The Austrian building type matrix

6.1 Single-family House(s)

In the first construction period, about 1918, in larger cities often spacious mansions with impressive reception areas and for that time typical masonry and stucco ornamentation were built. In rural areas the single-family houses were much more moderate, their appearance and construction depended on architectonical influences of the regions. The years after World War I were, because of a lack of materials and bad quality of the construction materials, caracterized by inadequate building construction, which are reflected in the higher energy demand values in comparison to buildings of earlier years. Predominantly simple plastered brick works without any façade decoration of stucco were built. After the second world war, there was, most of all, an urgent need to build quickly and cost-effectively. Due to the small profiles of the exterior walls, the buildings of this period usually don´t achieve today´s standards for noise and heat protection. Single-family homes were constructed mainly in housing developments in peripheral areas of towns and villages.

As a method to increase energy efficiency and housing quality in the energy crises since the 1970ies, thermal insulation and industrially prefabricated thermally insulated construction systems were established. Initially, the thermal protection was measured in decimeter wall thickness, later with the k value, and today construction elements are determinded by the U-value. The energy efficiency of buildings became more and more important, and as a result of the steadily reduced maximal permissible limits for heat losses, more thermally improved building construction elements and insulated windows were used.

With the increasing importance of energy efficiency, new building standards like low energy house standard (heating demand approximately 30–70 kWh/m²a) and later the passive house standard (15 kWh/m²a) were established. The first passive house in Austria was built in 1996. The trend today goes towards the low-energy or "Nearly Zero Energy" building. According to the European Directive EPBD[18] all new buildings from 2020 onward should be carried out in "Nearly Zero Energy building" standard.

[18] Source: http://www.epbd-ca.org/

Table 9: Overview of characteristic energetic values for single-family houses: characteristic U-values construction elements, characteristic energy-relevant building values living-area-related values [Sources: see chapter 4.1.1.]

SFH	I	II	III	IV	V	VI	VII
characteristic U-values construction elements							
roof	1.7	1.7	1.7	0.8	0.5	0.3	0.2
ceiling	1.1	0.8	0.8	0.7	0.4	0.3	0.2
wall	1.8	1.8	1.6	1.4	0.7	0.4	0.35
window	2.2	2.3	2.3	2.7	2.5	1.8	1.4
floor/cellar	1.2	1.2	1.2	0.8	0.5	0.5	0.4
characteristic energy-relevant building values							
HWB [kWh/m²a]	180–300	200–370	160–380	145–280	100–190	80–130	10–100
living-area-related values							
living area [m²]	125–155	110–140	110–140	125–155	140–170	145–175	145–175
Number buildings	235,723	129,086	194,442	489,397	246,757	159,118	173,525
living area national [m²]	30,583,052	14,350,763	22,944,091	65,375,704	33,945,697	22,186,226	25,978,316

6.2 Terraced House(s)

Terraced houses are architecturally and energetically different from multi-family houses, but they are not listed separately in the national statistics. Therefore no statements about the frequency of this building category can be made.

In the course of industrialization in the late 19th and in the early 20th century, working class homes were built in the form of terraced one-family or two-family houses. The economic and social changes after World War I led to the construction of many settlements with functional, small floor plans and plastered brick walls. After World War II, many homes had to be built in a very short time.

The floor plans were similar to the typical buildings of the years between the wars. The terraced houses of this period are particularly characterized by cost-effective and partly inferior materials. Not until the beginning of the 1960s, this trend changed and generous floor plans were built again. In these years industrially prefabricated sandwich constructions and composite construction methods were used for reduction of construction costs and for building physical improvements. As a result of the first oil crisis in 1973, the use of insulated building elements came up. Since then, there was an increasing demand for thermal protection of buildings. The building standards newly developed in the recent years like low energy housing and, since the 1990s, the passive-house standard was particularly tested and implemented in single and terraced houses.

Table 10: Overview of characteristic energetic values for terraced houses: characteristic U-values construction elements, characteristic energy-relevant values of building [Sources: see chapter 4.1.1.]

TH	I	II	III	IV	V	VI	VII
characteristic U-values construction elements							
roof	1.7	1.7	1.7	0.8	0.5	0.3	0.2
ceiling	1.1	0.8	0.8	0.7	0.4	0.3	0.2
wall	1.8	1.8	1.6	1.4	0.7	0.4	0.35
window	2.2	2.3	2.3	2.7	2.5	1.8	1.4
floor/cellar	1.2	1.2	1.2	0.8	0.5	0.5	0.4
characteristic energy-relevant building values							
HWB [kWh/m²a]	180–300	200–370	160–380	145–280	100–190	80–130	10–100

6.3 Multi-familiy House(s)

According to Statistics Austria this type is defined by two- to four-level residential buildings with about three to ten residential units.

In the Wilhelminian era, they used to build city mansions for multigenerational living. Mostly the very prestigious facades were organized by an impressive entrance and bay zones, facades were decorated by stuck ornamentation. Although the structural thermal protection was hardly taken into account, due to the very large masonry the heating demand of buildings of this construction period is often lower than in the following periods.

Multi-family houses from the interwar and postwar years have a high energy consumption due to the usually thin and uninsulated walls. In the 1970s and particularly in the 1980s, the insulation of the whole external building envelope spreaded out, resulting in a decreasing heating energy consumption.

Given the limited availability of fossil energy sources and in order to prevent environmental damage caused by CO_2 emissions, in the following years guidelines were adopted to define the maximum heating demand. This allowed a reduction of the heating demand per square meter for the new buildings. Today, a maximum heating demand of 54,4 kWh/m² is allowed for new buildings. [19]

[19] Source: OIB RL 6, Status: Mai 2011

Table 11: Overview of characteristic energetic values for multi-family houses: characteristic U-values construction elements, characteristic energy-relevant building values and living area-related values [Sources: see chapter 4.1.1.]

MFH	I	II	III	IV	V	VI	VII
characteristic U-values construction elements							
roof	1.7	1.7	1.7	0.8	0.5	0.3	0.2
ceiling	1.1	0.8	0.8	0.7	0.4	0.3	0.2
wall	1.4	1.4	1.3	1.1	0.6	0.4	0.35
window	2.2	2.3	2.3	2.7	2.5	1.8	1.4
floor/cellar	1.2	1.2	1.2	0.8	0.5	0.5	0.4
characteristic energy-relevant building values							
HWB [kWh/m²a]	130–230	140–270	150–270	100–205	80–140	60–100	10–80
living-area-related values							
living area [m²]	400–800	280–680	280–680	400–800	400–800	350–750	350–750
number ofbuildings	36,025	18,550	19,868	37,104	17,592	16,821	18,405
living area national [m²]	14,145,992	6,161,368	7,001,308	14,739,613	7,728,972	7,389,169	7,985,746

6.4 Apartment Blocks

This part describes large multi-family houses and multi-storey residential buildings with more than eleven living units, which are mostly located in larger towns.

In the urban areas residential buildings from the Wilhelminian era are typical, with masonry and stucco decorations on the front side and with simple masonries and due to later extensions partly very angled on the back side. From 1919 to the mid 1930s especially in the so called “Rotes Wien” (labour policy oriented Vienna) standardized dwellings with standard floor plans (38 or 48 m²) were built. In the big apartment blocks until 1944, 1- and 2- bedroom apartments with breakfast kitchen, kitchenette and bathroom/WC predominate. The economic growth of the 1960s lead to a significant increase in new residential buildings, for the first time in skeletal construction and new materials (lightweight concrete, boards). Quality and size of affordable, functional new building apartments were increasing, heating insulations were still missing. Growing demands on the thermal protection since the mid-1970s reduce the energy consumption of residential buildings regularly.

Tabelle 12: Overview of characteristic energetic values for apartment blocks: characteristic U-values construction elements, characteristic energy-relevant building values and living area-related values [Sources: see chapter 4.1.1.]

AB	I	II	III	IV	V	VI	VII
characteristic U-values construction elements							
roof	1.7	1.7	1.7	0.8	0.5	0.3	0.2
ceiling	1.1	0.8	0.8	0.7	0.4	0.3	0.2
wall	1.4	1.4	1.3	1.1	0.6	0.4	0.35
window	2.2	2.3	2.3	2.7	2.5	1.8	1.4
floor/cellar	1.2	1.2	1.2	0.8	0.5	0.5	0.4
characteristic energy-relevant building values							
HWB [kWh/m²a]	130–230	140–270	140–270	100–205	80–140	60–100	10–80
living-area-related values							
living area [m²]	>800	>700	>700	>800	>800	>800	>800
Number buildings	15,228	5,025	7,727	21,750	6,058	4,131	4,636
living area national [m²]	16,932,197	4,318,376	7,317,536	28,912,454	8,345,633	4,777,708	5,620,676

6.5 The Austrian Sub-Typologies

To define the buildings within the webtool, it was decided to create the following sub-typologies containing the building envelope elements as well as the technical building equipment.

The roof typology

In Austria there are mainly three roof types used:

- the tilted roof, double pitched, 30° roof pitch
- the tilted roof, kerb roof 45° roof pitched
- the flat roof, 7% down-grade

The ceiling typology

In Austria, the ceiling is very easy to refurbish when the attic is not used as living area. In these cases, it is quite simple to install (additional) thermal insulation. Often this is done in SFH and TH. In most of the MFH, especially in the bigger cities, the attic is refurbished thermally and then extended (additional living area, often sold as condominium suite). In general there are four types of ceilings:

- wooden construction
- steel-beam construction
- precast elements
- reinforced concrete

The wall typology

In Austria, the main material used to build the external walls of SFH and TH is brick or reinforced concrete with thermal composite systems. For MFH and AB often reinforced concrete with thermal composite systems have been and are still being used.

- brickwork
- reinforced concrete (with thermal composite systems)

The window typology

In the past (until the 1960s) it was typical to use single-glazed windows, in wooden frames. In the MFH and AB often box-type windows were used – that means the windows had an internal and an external casement. Later the use of composite windows (double-glazing) increased. From the 1990s onwards heat-protection glazing was established in the market. Nowadays there are also triple-glazing heat-protection windows existing. The window typology consists of the following four categories:

- single glazing, wooden frame
- single glazing, box-types
- douple glazing (composite windows)
- triple-glazing
- passive-house windows

The door typology

- wooden door
- metal door with thermal insulation

The floor typology

- wooden construction
- steel-beam construction
- precast elements
- reinforced concrete

7 How to use the brochure

The brochure introduces the national TABULA Typology and its possible refurbishment measures for Austria. The detailed data of the model buildings are presented in the national brochure.

The brochure is currently released in version 1.0 for download: http://www.energyagency.at/fileadmin/aea/pdf/Gebaeude/Tabula_broschure.pdf

The datasets for the particular buildings are shown in the building data sheets [see figure below]. It consists of 28 double-paged typology buildings descriptions and additional information: first the typology and its refurbishment stages, then details about the EPC, alternative energy systems to consider during refurbishing process, national certification programs and finally possible refurbishment measures in more detail.

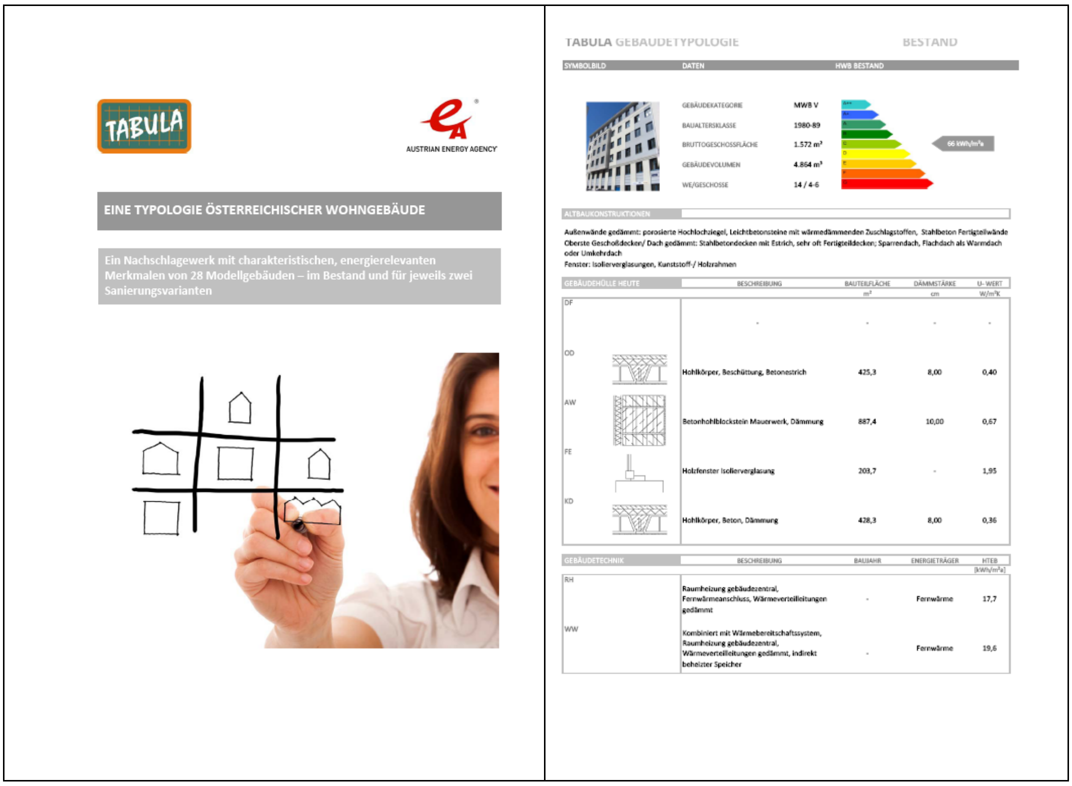
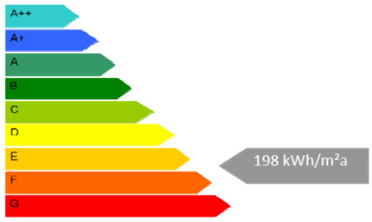


Figure 14: National Typology Brochure: front page and building data sheet for an existing building (building stock)

The datasets of the building typolopogy are presented in chapter 4. For each building type the status quo of the building is described on the first data sheet (see figure below). On the second data sheet two possible refurbishment variants are presented.

The following figure exemplarily shows the first page of a multi-family house data sheet, built in the period between 1920 and 1944.

GEBÄUDEKATEGORIE	MFH II
BAUALTERSKLASSE	1920-44
BRUTTOGESCHOSSFLÄCHE	369 m²
GEBÄUDEVOLUMEN	1.069 m³
WE/GESCHOSSE	4 / 3-4



ALTBAUKONSTRUKTIONEN

Außenwände ungedämmt: Vollziegelmauerwerk 29 bis 45 cm (geringere Wandstärken gegenüber Gründerzeithäusern), Stuckornamentik reduziert

Figure 15: National Typology Brochure: example of left double-page data sheet – general information on the building type

In the left corner there is as an picture representing a typical building of the respective building age class. Next to it the type, the building age class, the gross floor area, volume and the floors of the building are specified. On the right side the scale (desription see chapter 5.1) for this typical building is shown.

Then the more detailed description of the thermal envelope is provided: the building elements are named, a draft and a short description is given, the surface area as well as – if applicable – the thermal insulation layer thickness and finally the U-value of the building element are mentioned.

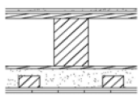
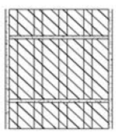
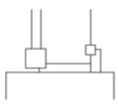
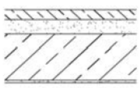
GEBÄUDEHÜLLE HEUTE		BESCHREIBUNG	BAUTEILFLÄCHE	DÄMMSTÄRKE	U- WERT
			m²	cm	W/m²K
OD		Holzbalkendecke, Beschüttung, Hobeldielen	127,9	-	0,90
AW		Vollziegel Mauerwerk	378,4	-	1,40
FE		Kastenfenster	35,7	-	1,40
KD		Stahlbetondecke, Beschüttung, Estrich	122,9	-	0,90

Figure 16: National Typology Brochure: example of left double-page data sheet – detailed description of the thermal building envelope

On the bottom of the page the technical system is described: there is a drawing of the installed heating system, a short description, the efficiency factor, the energy carrier and the heating losses in the generation and distribution (HTEB), as well as the details for the dhw-system.

GEBÄUDETECHNIK	BESCHREIBUNG	BAUJAHR	ENERGIETRÄGER	HTEB [kWh/m²a]
RH	Raumheizung gebäudezentral, Fernwärmeanschluss, Wärmeverteilleitungen gedämmt	-	Fernwärme	23
WW	Kombiniert mit Wärmebereitschaftssystem, Raumheizung gebäudezentral, Wärmeverteilleitungen gedämmt, indirekt beheizter Speicher	1995	Fernwärme	25,9

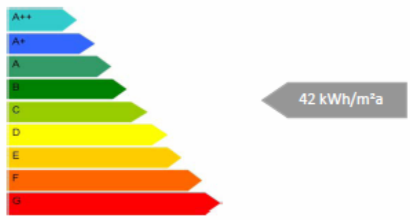
Figure 17: National Typology Brochure: example of left double-page data sheet – detailed description of heating and hot water systems

Using the status quo examples, on the right double-page the two refurbishment stages are described (see figure below).

klima:aktiv SANIERUNG

GEBÄUDEHÜLLE	BESCHREIBUNG	U-WERT W/m²K
OG	Aufdämmung 16 cm	0,4
KD	Aufdämmung 16 cm	0,4
AW	Wärmedämmverbundsystem 20 cm, gespachtelt, geklebt	0,15
FE	Tausch Fenster: Isolierglasfenster	1,4

HWB SANIERUNG



GEBÄUDETECHNIK	BESCHREIBUNG	ENERGIETRÄGER	HTEB [kWh/m²a]
RH	Raumheizung gebäudezentral, Fernwärmeanschluss, Wärmeverteilleitungen gedämmt	Fernwärme	0,2
WW	Kombiniert mit Wärmebereitschaftssystem, Raumheizung gebäudezentral, Wärmeverteilleitungen gedämmt, indirekt beheizter Speicher	Fernwärme	20,1

Figure 18: National Typology Brochure: example of right double-page data sheet – detailed description of heating and hot water systems

The first refurbishment option represents the minimum requirements for refurbishment according to the guideline no. 6 of the Austrian Institute for Civil Engineering. The second part shows the advanced stage refurbishment represented by the advanced requirements according to the national climate protection programme [see chapter 4.4.]. The thermal refurbishment measures and the achieved new U-value of the building element as well as the technical refurbishment measures are defined and the new energy demand for technical service is documented.

For the brochure the calculations were checked with the energy certificate software “ETU Gebäudeprofi PLUS”. To ensure the comparability of the measures, insulation materials were restricted to commercially used materials (no special environmental requirements).

Regarding the renovation measures of the heating systems, following assumptions were made:

- Those heating systems were installed which, according to Statistics Austria, currently have the highest market share in the respective building age class.
- For all building types and construction periods the pipes are in the heated section, if there is no basement, and in the unheated area, if there is a basement.
- The insulation of the pipes is assumed for all types 2/3 of the pipe diameter.
- The heating system of the stock is always assumed from the year 1995 (at the last construction period 2001–2010 a system of the year 2005 is applied).
- Renovation 1 and 2 are each calculated with condensing technology.
- The system temperatures are as follows:
    - Status quo: 90/70 °C
    - Renovation 1: 70/55 °C
    - Renovation 2: 55/45 °C
- The domestic hot water (DHW) preparation is effected centrally for all types.
- For MFH, TH and AB a circulation line is provided.

The final energy demand and its energy savings of the different refurbishment measures are shown at the bottom of the right double-page data sheet. Multiplied by CO_2 coefficients[20] the CO_2-emission reduction potential can be estimated.

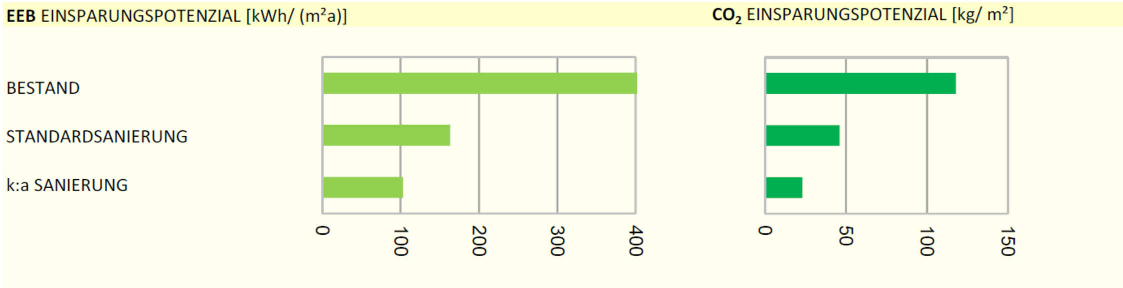


Figure 19: National Typology Brochure example of right double-page data sheet – final energy demand and CO2 saving potentials

[20] Source: OIB-RL 6 status Mai 2011

8 Conclusions

The aim of the TABULA project was the development of a harmonised building typology for European countries by using reference buildings. In Austria this could successfully be accomplished by combination of available EPC data information out of ZEUS database, literature sources and the national microcensus “buildings and dwellings”.

The steps to generate the National Building Typology Austria are described in this report. On the one hand, the outcome is available as brochure (download via http://www.energyagency.at/gebaeude-raumwaerme/aktuelle-projekte/tabula.html), on the other hand, the webtool allows for cross-country-comparisons between the several partners, *(http://www.building-typology.eu)*.

The basic national building typology, as defined and presented in the national brochure, attracted wide interest to be used as a basis for other investigation projects. Within the project scenario analysis for the national final energy demand and energy saving potentials were done and compared to the national statistical consumption data. The final energy demand results from TABULA scenario analysis approaches very close to national statistical data.

If there is data available from all participating countries, national building typologies will be comparable among each other and – supported with statistic values – this could serve for energy saving projections and CO_2 savings analyses as a basis for European energy policies. In the long run, the national building typologies can be used for forecasting and evaluating energy savings and carbon dioxide emission reduction potentials for several European countries.

Beside the possibility to use the typology as an instrument for potential analysis on regional and national level, the building typology can be used for initial advice or to make the end-user aware of possibly necessary refurbishments.

9 Abbreviations

AB	appartement blocks
EPBD	Energy Performance of Buildings Directive 2002/91/EG and 2010/31/EU
EPC	Energy performance certificate
MFH	multi-family house(s)
MS	member state (of the European Union)
TH	terraced house(s)
SFH	single-family house(s)
GFA	gross floor area (m²)
RB	residential building(s)
NRB	non-residential building(s)
OIB-RL 6	OIB- Richtlinie 6 - guideline no. 6 of the Austrian Institute for Civil Engineering
HGT	Heizgradtage – Heating degree days
$HGT_{location}$	Heizgradtage – Heating degree days location of the building
WWWB	Warmwasserwärmebedarf – domestic hot water heating demand
HTEB	Heiztechnikenergiebedarf – heating losses in the generation and distribution
REF	Reference climate (see chapter 5.1.)

- HWB: Heizwärmebedarf – HD: Heating demand: [kWh/m²a] annual heating demand calculated on the basis of the building-specific consumption profile per m² gross conditioned floor area. The specific heating demand is a comparison value to describe the thermal quality of the building envelope. Based on a reference climate for space heating, it indicates how much energy is needed per year and square meter to maintain a temperature of 20°C, assuming a standard consumption during the heating season.

- HTEB: Heiztechnikenergiebedarf – heating demand for heating technology [kWh/m²a] annual heating demand calculated on the basis of the building-specific consumption profile per m² gross conditioned floor area. The HTEB corresponds to the amount of energy that goes lost in heat generation and distribution. It is composed of HTEB-TH (space heating) and HTEB-WW (domestic hot water).

- WWWB: Warmwasserwärmebedarf – domestic hot water heating demand: [kWh/m²a] annual hot water heating demand calculated on the basis of the building-specific consumption profile per m² gross conditioned floor area. The WWWB corresponds to that amount of energy that has to be supplied in order to gain the required amount of hot water, without considering the heat losses of the system technology.

- EEB: Endenergiebedarf – final energy demand [kWh/m²a]: annual final energy demand calculated on the basis of the building-specific consumption profile per m² gross conditioned floor area. The EEB for residential buildings corresponds to the externally supplied energy amounts, taking into account the losses of heating and hot water systems to cover the HWB. Thus, the final energy demand covers not only the demand for heating and domestic hot water, but also the energy losses caused thereby.

$$EEB_{\text{residential buildings}} = HWB + HTEB + WWWB$$

- CO_2 [kg CO_2/m²a] annual CO_2equivalent emissions calculated on the basis of the building-specific consumption profile per m² gross conditioned floor area. The CO_2 emissions are composed of the final energy demand multiplied with the emission factors per energy carrier.
- OIB RL 6 – The guideline no. 6 of the Austrian Institute for Civil Engineering from April 6, 2007 treats the issues of energy saving and thermal protection and represents the national basis for the related standards of the provinces. As of 1 January 2012, a revised version will provide, beside of the heating and cooling demand, information about the primary energy demand and the CO_2 emissions will be available in the energy certificate.
- EPBD: The EU Directive "Energy Performance of Buildings Directive – EPBD" adopted in 2002 and revised in 2010 requires EU member states to set minimum standards for energy efficiency of new or renovated buildings and to introduce Energy performance certificates.

10 Annex 1 – Non-residential buildings

Existing typology concepts

Ecofacility database

The project “ecofacility” database is a benchmark database of the national klima:aktiv program and was founded in February 2004. It is used by the klima:aktiv (http://www.klimaaktiv.at) commercial building consultants for construction and renovation, to perform a first rough check within an energy consultation. After entering the data, the consultant is able to compare and evaluate the electricity, water and energy consumption. The online database assists the energy consultant by offering an automatic estimation of the energy efficiency of the building. In a second step, on the bases of a short report, the energy consultant gives general energy saving advices and then, in a third step, proposes necessary energy saving measures.

Currently, a total of over one thousand buildings are recorded in the database. There exist benchmarks for the following **operating modes**: **Office building, tourism, school, event centers, homes trade, parking garages.** For each building, data for annual electricity, water and heat consumption, gross floor area, number of nights, beds, equipment (mechanical ventilation, air conditioning, canteen, laundry, kitchen, gym, heavy evening use etc.), class number etc., is collected.

ZEUS and Immo-ZEUS database

Statistics Austria provide only little information about non-residential buildings, and the requested data are not available. The Immo-ZEUS EPC-database (http://www.immozeus.at/), developed for non residential buildings only, currently contains 1690 data sets of non-residential buildings. The Austrian Energy Agency and gizmocraft operate the online database. Immo-ZEUS is available to all construction companies, real estate companies and Energy performance certificate advisers. It is an Internet software, which makes possible that the EPC data from the respective calculation programs is automatically transferred into an Internet address. If necessary, the data of each building can be updated when there are changes in ownership.

The datasets of the non residential buildings from the years 2003 to 2010 were used for the TABULA analysis and to work out a draft classification scheme. More than 50 EPCs were available for the following building categories: “operational buildings” like factories or service buildings, remaining conditioned non-residential buildings, schools, trade buildings. Less than 50 EPS were available for the categories: event centers, offices, hotels and hospitals. [status 2010]

To get still more representative information out of the databases, more buildings will have to be recorded. Therefore, to begin with, the following classification types and age classes were decided to be established, taking into consideration also the before described ecofacility benchmark database.

Draft classification scheme for non-residential buildings

Within the TABULA project, the data of ZEUS and ImmoZEUS databases were evaluated in order to check their usability for establishing a non-residential building typology. Following non residential building typology is proposed in accordance to the national available data:

- **Building types:** operational buildings, school, trade buildings
- **Construction year classes:**
  - I until 1918
  - II 1919–1980
  - III 1981–2000
  - IV 2001–2010
- **Possible Supply system categories:** Oil, Natural gas, District heating

Proposed proceeding / link with current national activities

The following sources for the proceeding for the classification scheme are available: "Handbuch Baustelle Schule- Leitfaden zur ökologisch nachhaltigen Sanierung von Schulen", E.Haselsteiner, et. al. BMVIT, 47b/2010; „Handbuch für kommunale und regionale Energieplanung – Handbuch KREP 2000", Joanneum Research Forschungsgesellschaft mbH, 2001; „Handbuch für Energieberater", Joanneum Research Forschungsgesellschaft mbH, 1993

The following sources for data of concrete example buildings are available: Best practise eco-facility projects and ZEUS as well as ImmoZEUS database.

11 Annex 2 – Energy certification databases

Databases in Austria

In Austria, the submission of Energy performance certificates (EPC) has been the precondition to receive public housing subsidy for construction or renovation of residential buildings for many years now. Since the EPBD implementation has become the responsibility of the federal provinces, EPCs according to EPBD are also needed when applying for building construction permission.

On a national level, an amendment of Austria's law concerning buildings and residences registry (GWR) appoints Statistics Austria to act as service provider in setting up energy databases.

Another initiative that was put in place in the course of the implementation of the EPBD 2002/91/EC is the online database ZEUS, which was established to handle housing subsidy procedures. The EPC center Vorarlberg has implemented another EPC database which is used only within this province.

GWR System (GWR = Buildings and Residences register)

The new Adress GWR II System is operating since March 2010. Compared to the former GWR I Online System, it has been improved (e.g. input mask) and expanded in response to the building codes of the 9 Austrian federal provinces and the Residential Act. Moreover, the GWR EPC database has been integrated into the GWR system, although the GWR EPC database is not yet operating.

Procedures to enable the aquisition of EPCs

In 2010, the amended GWR Act has come into force. The EPC database is not yet working, however, for reasons of testing and for legal reasons as well. EPC issuers of each province have to be obliged by law to notify each EPC issued to GWR. At the same time they could be authorized to look at their EPCs in GWR at any later point of time.

The EPCs already recorded in the ZEUS database will be entered into the GWR in the course of permission procedures and funding of new buildings or renovations.

When automatically reading in the EPCs, analogue addresses have to be identified, in order to assign an own GWR number to each object. On buildings level, 99.7% of the objects existing are already recorded. On residences level, the data stock is by far smaller. A uniform nationwide system of numbering the apartment doors would be necessary, as it is existing only in two provinces, so far. Not until all provinces will have established a uniform door numbering, the GWR EPC database will be able to come into operation.

Furthermore, there are considerations concerning a kind of harmonized building description form to be filled in by architects and builders. All GWR-relevant data would have to be entered into this form, thus simplifying the procedure of transferring e.g. area data from digital plans into GWR.

ZEUS database

The ZEUS database having become the widest-spread EPC database in Austria over the past 6 years, covering three provinces and being open to the private sector as well, only this Austrian database was analyzed in more detail and its data stock used for the TABULA project. In general, the information needed for TABULA is covered by the datasets stored via ZEUS. At the moment, about 60% of EPCs of new buildings and 40% of EPCs for reconstructed buildings are stored in the ZEUS databases. As a matter of fact, the biggest lack of information lies within the technical information: the technical data for heating and domestic hot water often is not available (the older subsidy schemes did not require a description of the technical equipment).

Analysis of the EPC datasets and the use for the TABULA project

"Landesregierung" Salzburg, "LandesEnergieVerein" Styria and "energie:bewußt" Kärnten, operator of the ZEUS instances have the opportunity to evaluate data in course of EPC calculation such as decrease of heating energy demand or increase of thermal quality of building envelope during a defined period of time. The implementation of ZEUS in other federal provinces is currently under discussion.

In the Austrian provinces already using ZEUS, the electronic submission of the EPC is the precondition to receive a public subsidy for construction or renovation of residential buildings. Consultants use ZEUS as archive and to keep their EPCs organized. Building owners (companies and privates) access their EPCs via ZEUS via secure link. Companies (e.g. property developers) can implement their own approval process inside ZEUS for EPCs that are stored on behalf of their company.

ZEUS is a software for electronic data management of Energy performance certificates. It's an online database to archive and process EPCs electronically via internet. The EPCs are calculated by software programs. Mainly used software programs provide a direct interface to ZEUS. This allows pushing EPCs to ZEUS by click. The certificate itself (PDF version) and a number of data as result of the calculation are transferred online into the ZEUS database.

Conclusions

For national evaluations or investigation projects like TABULA especially the interface between the database and the EPC calculation program is essential for a specific data analysis. For precise data analysis all the exact information about the geometries of the buildings and its orientations needs to be stored in the XML version. Until today these informations are stored in the EPC PDF only. Furthermore, there is no possibility so far to load the XML data into an EPC calculation program to facilitate and allow for a fast data input in order to change and adapt the stored EPCs for investigation purposes.

The main focus will remain on establishing a homogenous data interface standard and way of processing and storing EPCs. The usability of EPC maintenance user interfaces has to be increased so that development methods will be aligned to be able to deal with future challenges.

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Versorgungssicherheit
Wettbewerbsfähigkeit
Nachhaltigkeit
Perspektiven

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